Survey of a World War II Derelict Minefield with the Fluorescence Imaging Laser Line Scan Sensor

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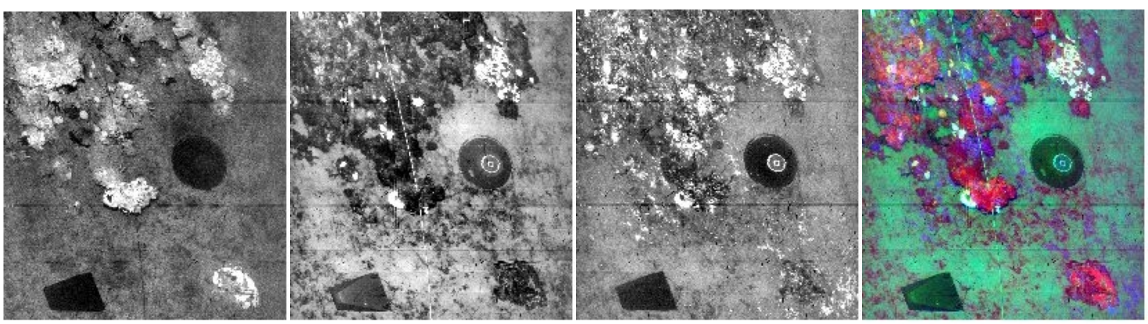
LONG TERM GOALS

This short-term project supports the long-term goals of the "Coastal Benthic Optical Properties Fluorescence Laser Line Scan Sensor" (CoBOP/FILLS) project (Award #N001499WX30131) summarized in its report. Specifically, the long-term goal is to **extend MCM capabilities into highly cluttered environments**.



The primary sensor technology currently employed to detect and classify mines is acoustics. Sonars perform this mission admirably in acoustically benign environments. However, their performance degrades rapidly in cluttered environments. Our prototype Fluorescence Imaging Laser Line Scan (FILLS) sensor[1,2,3,4,5] has demonstrated that fluorescence imagery provides strong signatures which may be used to separate clutter from mines. The images above show the red, green, and yellow fluorescence channel images (along with a pseudocolor representation of these three fluorescence channels) of mine like objects (MLOs) in a coral reef. It can be expected that sonars would have great difficulty in this environment. On the other hand, the FILLS signatures of the MLOs exhibit a clear and distinct contrast from the background. Specifically, the MLOs present a near-zero FILLS signature in the red and yellow fluorescence channels, while the background sediments and coral present much stronger signatures in these channels. These contrasting signatures may be exploited to rapidly detect and classify MLOs in highly cluttered environments. By so doing, this technology has the potential to extend MCM capabilities into highly cluttered environments.

This detection and classification capability has been achieved without degradation in the capability of laser line scan sensors to identify targets. The image below shows the elastic scatter channel image acquired simultaneous with the acquisition of the fluorescence channel images shown above. The details evident on the MLOs suggest the image quality this technology is capable of providing to the

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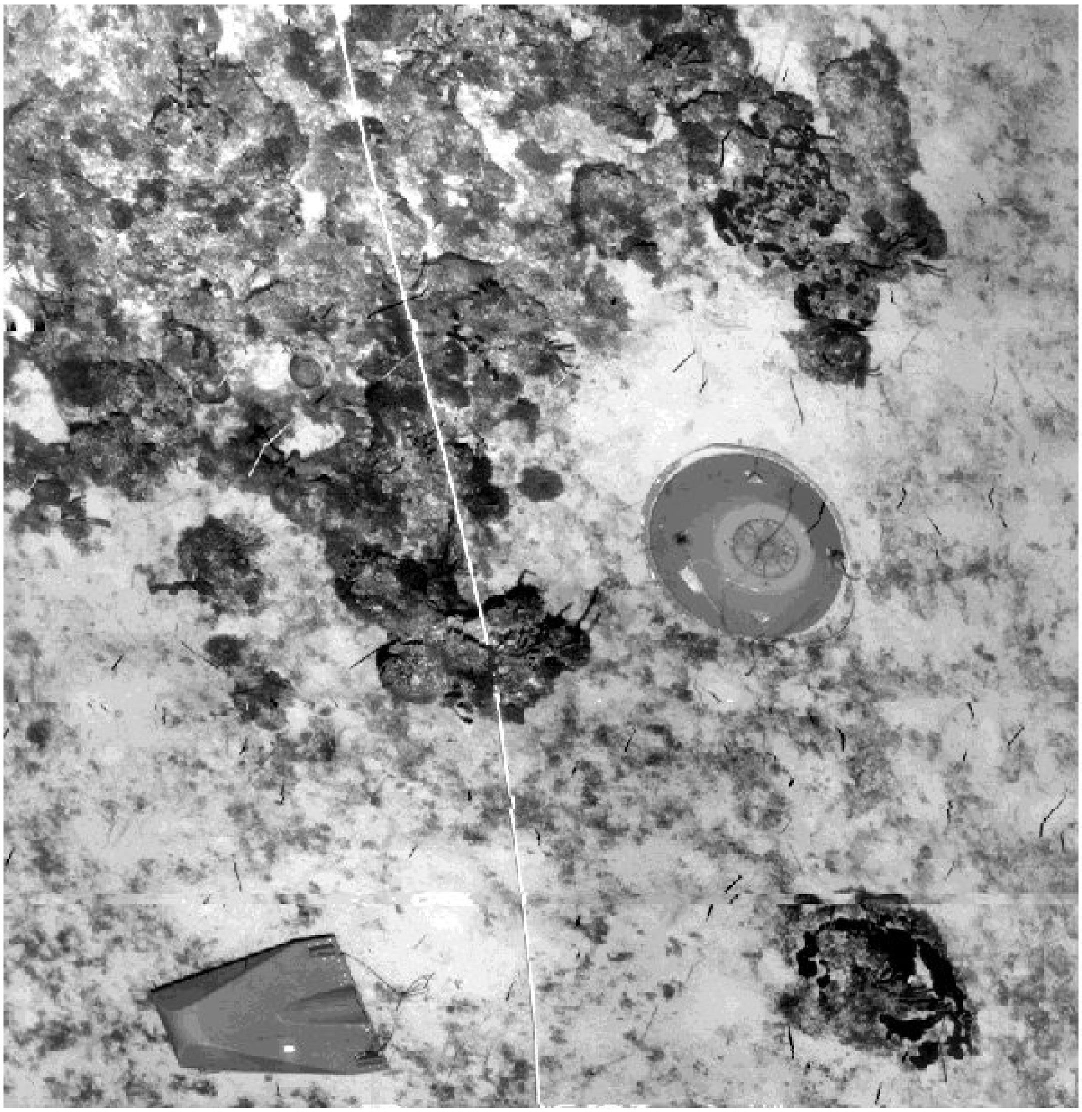
fleet for identification of targets. Combined with the detection and classification capability provided by the fluorescent channels, **FILLS technology has the potential to provide a complete MLO detection, classification, and identification capability in highly challenging environments**.



OBJECTIVES

The FILLS images above show signature contrasts for MLOs placed in the water days before the images were taken. They show marked contrast between the fluorescence signatures of the MLOs and the natural backgrounds. Biofouling of the MLOs will occur over time as they are left in the water. This biofouling is expected to change the fluorescence signatures of the targets. One of the objectives of the CoBOP/FILLS project is to characterize this "optical aging" of MLOs.

The primary objective of this project was to obtain and evaluate FILLS images of a "long-term end member" of optical aged MLOs. Specifically, our objective was to obtain FILLS images of MLOs

from a (now derelict) minefield laid during World War II. This minefield contains targets that have "aged" for more that fifty years.

FILLS image data is acquired as 12 bit digital data. Since image display devices (computer monitors and printers) have a useful dynamic range of 8 bits or less, this data is processed and enhanced before it is displayed or printed. Typically this is done as a post-processing step[6,7]. The secondary objective of this project was to implement these algorithms in real time.

The third objective was to instrument the active depressor towed body with ambient light sensors. These ambient light sensors can be used to measure solar stimulated environmental fluorescence and to quantify the impact of ambient light noise on laser line scan imagery.

APPROACH

This survey was carried out through cooperation of three groups. "The fouling of mine casing surfaces by fluorescent organisms" project (Charles Yentsch and David Phinney) located the minefield and GPS coordinates of a mine/anchor pair within the field. They also provided environmental measurements, photographic and videographic documentation of this mine/anchor pair, deployed fluorescence targets prepare by Charles Mazel from PSI, and contracted with Harbor Branch Oceanographic Institute (HBOI) for the R/V Sea Diver, from which the FILLS sensor was deployed. Raytheon, through the "Underwater object identification in laser line scan imagery" project, provided FILLS sensor operators, and will use the data generated to assess their proprietary target cueing and object identification algorithms [8]. CSS provided the FILLS sensor integrated into an active depressor towed body, a deployment crew, and real-time and post processing image processing and enhancement. This survey was scheduled to immediately follow the CoBOP LSI test.

WORK COMPLETED

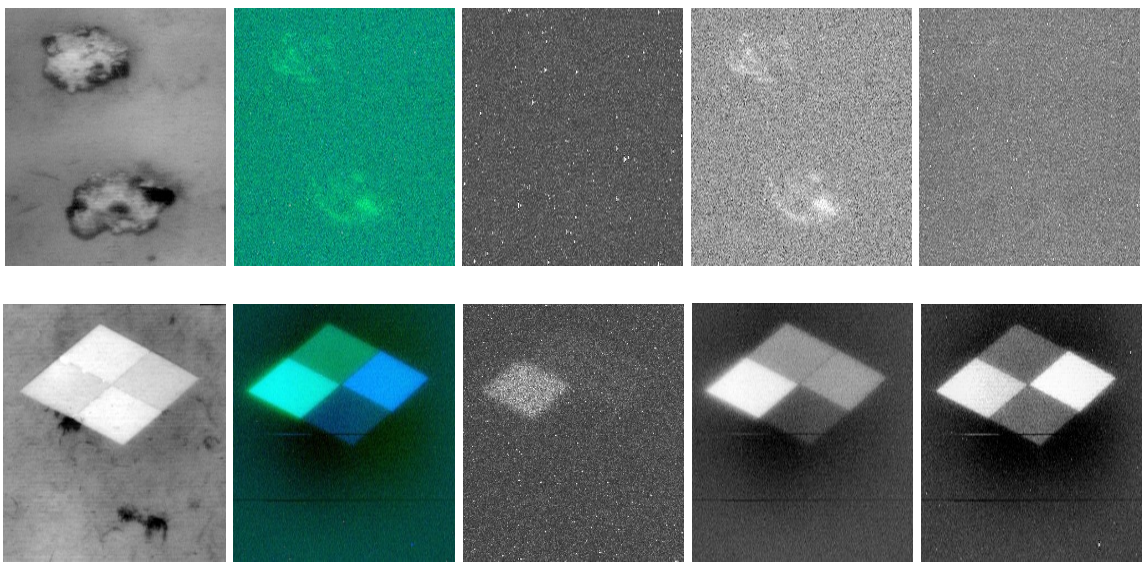
FILLS image enhancement routines developed by CSS for the CoBOP project were implemented to run in real time on Windows NT 4.0 based hardware in accordance with IT-21 guidance. A Windows NT device driver was written for the laser line scan telemetry card developed by Raytheon for the EOID Sensor for the MARCOT exercise. (CSS contracted with Lee Mowat of Craftech Software Designs to develop this device driver.) In addition to providing the real-time image enhancement, the Windows NT approach provides for continuous recording of the full raw digital data stream on 35 gigabyte Digital Logical Tapes (DLTs).

Ambient light sensors were purchased from Satlantic and integrated into the active depressor towed body. The two FILLS channels that had failed at the CoBOP test at Lee Stocking Island were repaired by Raytheon under funding from the CoBOP project. This required significant tow body disassembly and reassembly to be performed by CSS.

The survey was conducted on June 13, 14, and 15, 1999. Imagery was acquired of the mine/anchor pair located by Yentsch and Phinney, of the PSI fluorescence targets, and of other mine-like objects located in the area.

RESULTS

The water conditions at the test site were remarkably harsh, as evidenced by the subimages (elastic, fluorescence pseudocolor, and red, green, and yellow fluorescence channels, respectively) of the mine/anchor pair and of the PSI fluorescence target panels. The elastic channel MLO image, while significantly degraded by the turbid water, indicates massive biofouling. The fluorescence channels of the FILLS sensor were operated at maximum gain to attempt to compensate for the attenuation caused by the turbid water. The fluorescent signal from the fluorescence target panels was very weak, and post-processing gain was applied to the imagery in order to make the fluorescence signals discernable. Essentially no fluorescence signal was discernable from the mine/anchor pair. (The excess noise evident in some of the imagery is due to gain applied in post-processing while attempting to discern a fluorescence signal.)



While analysis of this data has not yet been completed, these results can be used to bound the fluorescent signature of the biofouled MLOs. Since the fluorescent signals of the biofouled MLOs is weaker than that of the fluorescence panels, and since the fluorescence panels were designed to give fluorescence signals that are comparable to that of the corals, we can conclude that the biofouling of these MLOs has not added a fluorescent signature to these MLOs that is comparable with the fluorescence signatures of corals. Never the less, it is possible that a significant fluorescence signal contrast exists between the MLOs and the background, but the turbid water attenuated these signals to the extent that the signals were not discernable with the FILLS sensor.

IMPACT/APPLICATIONS

The turbid water environmental conditions encountered at the test site has made interpretation of the data problematic. Charles Mazel plans to make *in situ* measurements of the fluorescence signatures of the mine/anchor pair and the surrounding sediment. This data will allow a more definitive interpretation of our data.

TRANSITIONS

The Windows NT device driver developed by this program was transitioned to the EOID Sensor, and was used at the MIREM/GOMEX exercise in September, 1999. Ambient light sensors were also deployed with the EOID Sensor at MIREM/GOMEX, but not exercised since EOID was tasked for nighttime operations only.

The results from this test will impact the selection of technology for the Advanced EOID sensor.

RELATED PROJECTS

As indicated above, this project was executed in close coordination with "The fouling of mine casing surfaces by fluorescent organisms" project (Charles Yentsch and David Phinney) and the "Underwater object identification in laser line scan imagery" project (Bryan Coles). In addition, it used the fluorescence panels produced by Dr. Charles Mazel.

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